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(19) (CA) **CANADIAN PATENT** (12)

(54) Recovery of Heavy Oil

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ABSTRACT OF THE DISCLOSURE

RECOVERY OF HEAVY OIL

Heavy crude oil is recovered from tar sands by treatment with an aqueous solution containing a surfactant, e.g., an alkyl aryl sulphonate and a hydrophilic alkylene oxide polymer, e.g., polyethylene oxide.

Adding the alkylene oxide polymer enables the surfactant to be used in lower concentration and/or recovery to be increased.

RECOVERY OF HEAVY OIL

This invention relates to a method for the recovery of heavy crude oil, especially from tar sands.

As reserves of conventional crude oils (approximately 15° to 30° API) decline, increasing importance will be attached to efficient methods for recovering heavy crude oils (8°-12° API) and the even heavier bitumens (less than 8° API). Most bitumens are associated with minerals such as clays and quartz, and are known as tar sands.

The Alberta tar sands are among the largest deposits of their kind in the world and are estimated to contain about one trillion barrels of bitumen in place. The Athabasca region alone has reserves of 250 billion barrels. About 0.7 million acres of the Athabasca deposit is overlain by 150 ft, or less, of overburden and is potentially capable of being mined from the surface. The remaining 16.6 million acres are at such depths that the bitumen can only be recovered by in-situ methods.

The crude bitumen occurs in beds of sand and clay, usually partly connected together, and in porous carbonate rocks.

In high grade tar sand, the pore space is filled with bitumen (typically 15-20% weight) and water.

In lower grade tar sands, i.e., containing less than 10% by weight bitumen, clusters of small particles exist within the framework formed by the coarse inorganic grains. These particles, known as fines, are saturated with water. Thus the amount of connate water in the tar sand increases with increasing fines



content.

The bitumen typically has an API gravity of 7° and is denser than water at room temperature but becomes lighter than water at elevated temperatures.

5 In the case of deposits near the surface the overburden may be removed and the tar sand recovered by open cast mining.

Mined tar sands are refined by the hot water process. A description of this process is given in USP 4 474 616.

10 In broad summary, this process comprises first conditioning the tar sand, to make it amenable to flotation separation of the bitumen from the solids. Conditioning involves feeding mined tar sands, hot water (80°C), an alkaline process aid (usually NaOH), and steam into a rotating horizontal drum wherein the ingredients are agitated together.

15 During conditioning, the mined tar sand in which the bitumen, connate water and solids are tightly bound together becomes an aqueous slurry of porridge-like consistency, wherein the components are in loose association.

20 The slurry leaving the drum is screened to remove oversize material and then flooded or diluted with additional hot water.

The bitumen is then recovered by primary and secondary froth flotation.

25 This process suffers from the disadvantages that bitumen/water emulsions are formed and the separated water contains colloidal dispersions of clay, fines and oil which are extremely stable and present serious problems in their disposal.

30 For deposits at a greater depth, the technique of jet leaching can be employed. Jet leaching is a known technique for the extraction of tar sands which comprises drilling and fixing casing until the pay zone is reached. The mineral is then fragmented by directing high velocity jets of water onto it and the bitumen is pumped to the surface, leaving most of the solid particles downhole.

35 An alternative approach for deep deposits is the use of cyclic steam stimulation to recover the bitumen. Cyclic steam stimulation is otherwise known as "huff and puff". In this process, steam is

injected and the bitumen produced through the same well. The steam is injected down the well for several weeks. When it is turned off, bitumen flows freely up the well for about one week, after which it has to be pumped to the surface. Pumping can usually be continued
5 for several months before more steam must be injected.

In all these methods, oil recovery is assisted when the sand is water wet and hindered when it is oil wet.

In the case of Athabaskan tar sands, most of the sand is water wet and therefore amenable to oil recovery.

10 The use of surfactants to improve recovery has also been reported, see CIM Bulletin, March 1979, pages 167-168, but the improvement compares unfavourably with that achieved by the use of sodium hydroxide. Higher concentrations of surfactant are required to achieve approximately similar improvements in recovery.

15 We have now discovered that adding a hydrophilic alkylene oxide polymer to the surfactant enables the surfactant to be used in lower concentration and/or recovery to be increased.

Thus according to the present invention there is provided a method for the recovery of heavy crude oil from heavy crude oil
20 associated with a solid inorganic substance (and optionally water) hereinafter referred to as the material, which method comprises treating the material with an aqueous solution containing a surfactant and a hydrophilic alkylene oxide polymer and recovering the heavy crude oil.

25 Suitable surfactants include anionic and nonionic surfactants. Anionic surfactants are preferred since the heavy crude oil is recovered as an oil in water emulsion which when separated is substantially free from solids and water.

30 Suitable anionic surfactants include alkyl sulphates and alkyl aryl sulphonates.

Suitable polymers include polyethylene oxides of molecular weight in the range 1,000 to 1,000,000.

Suitable concentrations of surfactant and polymer are each in the range of 0.01% to 5%, preferably 0.1 to 2.0%, by weight of the
35 solution.

5 The treatment is suitable for both previously mined deposits and for in-situ recovery from a reservoir, for example jet leaching or cyclic steam stimulation as hereinbefore described.

For previously mined deposits treatment is preferably effected at a temperature in the range 40° to 90°C.

10 The invention is illustrated with reference to the following Examples, and related Figures attached.

Figure 1 is a graph representing the results of a first series of tests showing the relationship between polymer and surfactant concentration (as the abscissa) and bitumen recovery (as the ordinate).

Figure 2 is a graph representing the results of a second series of tests showing the relationship between extraction time (as the abscissa) and bitumen recovery (as the ordinate).

20 Figure 3 is a graph representing the results of a third series of tests showing the relationship between pH (as the abscissa) and bitumen recovery (as the ordinate).

Examples

The material studied was a high grade Athabasca tar sand containing approximately 16% by weight bitumen homogeneously distributed throughout the sand mix.

25 A weighed sample of tar sand (typically 0.5g) and a measured quantity of the extraction medium (10 ml) were placed together in a round bottom flask which was immersed in a thermostatted bath. A water cooled condenser was fitted to minimize evaporative losses. Extractions were carried out without any agitation at 100°C for 10 minutes, except where otherwise stated.

35 The amount of bitumen removed from the tar sand was quantified gravimetrically after separation from the extracting medium and the free bitumen. The extracted sand was washed with double distilled water until all free bitumen had been removed. The sand was then filtered

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through a sintered glass funnel and dried in an oven at 50°C to constant weight.

Example 1

5 A series of tests were carried out using (a) a polyethylene oxide of average molecular weight 8,000, (PEG 8000), (b) sodium dodecyl benzene sulphonate, (SDBS), and (c) various combinations of (a) and (b).

10 The optimum concentration of PEG 8000 in conjunction with 5% by wt SDBS was found to be 0.5%. Little increase in recovery was observed at higher concentrations of PEG 8000. Using this lower concentration of PEG 8000, the concentration of SDBS was optimised. The maximum recovery (96%) was measured at a concentration of SDBS of 1.5%. Decreasing the concentration of SDBS resulted in a marginal
15 decrease in recovery at concentration as low as 0.5%.

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SDBS, 93% recovery was still achieved.

The results are set out graphically in the accompanying Figure 1 and clearly show the synergistic effect of the combination.

Example 2

5 A further series of tests was carried out to study the effect of extraction time on bitumen recovery using (a) a 5% solution of SDBS and (b) a solution containing 0.5% SDBS and 0.5% PEG 8000.

The results are set out graphically in the accompanying Figure 2.

10 The presence of the polymer has little effect on the rate of recovery over the first few minutes of the process. However, at time greater than about 2 minutes, recovery is increased considerably by the polymer/surfactant mixture compared to the surfactant alone.

Example 3

15 By way of comparison, a series of tests were carried out to show the effect of sodium hydroxide alone at various pH's and temperatures.

20 The effect of pH on recovery was studied at 70°C and 100°C over a pH range of 10-14. In the presence of NaOH at 70°C, the maximum recovery, 53%, was found at pH 11.7. Increasing the temperature of the extraction to 100°C had two effects: firstly, the recovery at the optimum pH increased to 61% and, secondly, the process became less sensitive to changes in pH, although still sensitive. At both
25 temperatures, however, there was little observed recovery outside the pH range 10-13.

In order to investigate the effect of added electrolyte, the experiments at 70°C were repeated in the presence of 0.1 M NaCl. As shown in Figure 3, this had little effect on the amount of bitumen
30 outside the pH range 10-13.

The results are shown graphically in the accompanying Figure 3 and clearly show the inferiority of sodium hydroxide to either the surfactant or polymer and still more to the synergistic combination.

35 Thus the experiments show that not only is the combination of SDBS and PEG 8000 superior to either component alone or to NaOH, it

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is also less sensitive to the concentrations of the components added. This is a considerable advantage in operations in the field.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method for the recovery of heavy crude oil from heavy crude oil associated with a solid inorganic substance, the material, which method comprises treating the material with an aqueous solution containing a surfactant and a polyethylene oxide of molecular weight in the range 1,000 to 1,000,000 and recovering the heavy crude oil.
2. A method according to claim 1 wherein water is additionally present in the material.
3. A method according to claim 1 wherein the surfactant is an anionic surfactant.
4. A method according to claim 3 wherein the anionic surfactant is an alkyl sulphate or an alkyl aryl sulphonate.
5. A method according to claim 1 wherein the concentrations of surfactant and polyethylene oxide are each in the range 0.01 to 5% by weight of the solution.
6. A method according to claim 5 wherein the concentrations of surfactant and polyethylene oxide are each in the range 0.1 to 2.0% by weight of the solution.
7. A method according to claim 1 wherein the treatment is effected at a temperature in the range 40° to 90°C.

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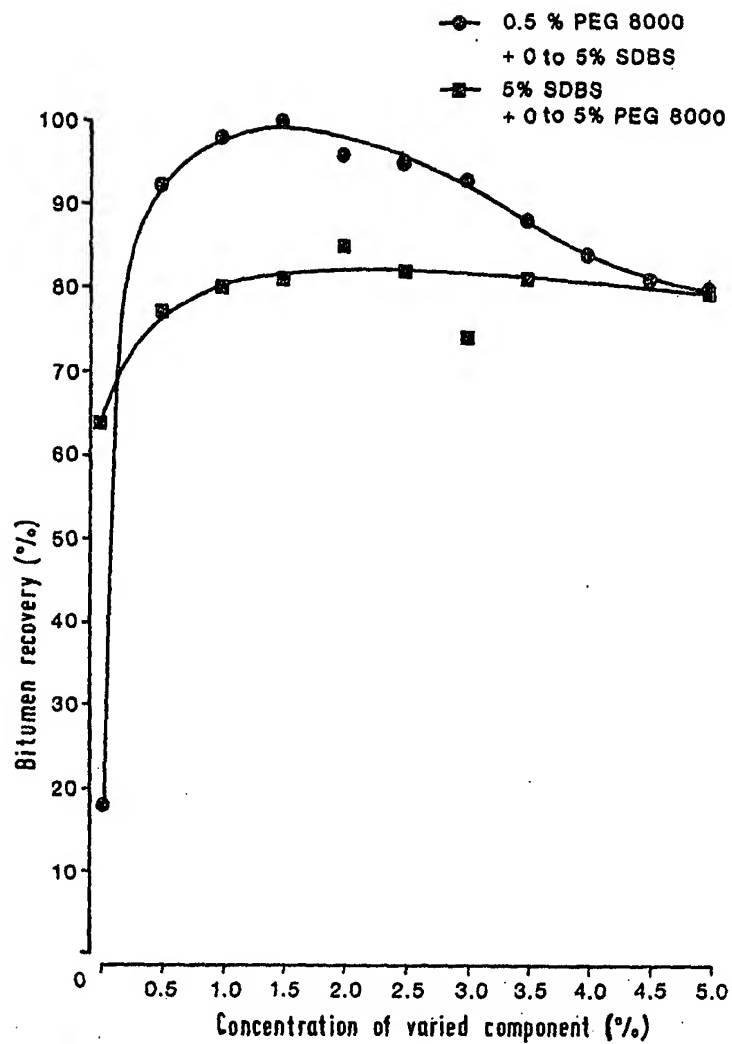


Fig. 1. Bitumen recovery vs polymer and surfactant concentration.
Mixtures of SDBS and PEG 8000 at 100°C

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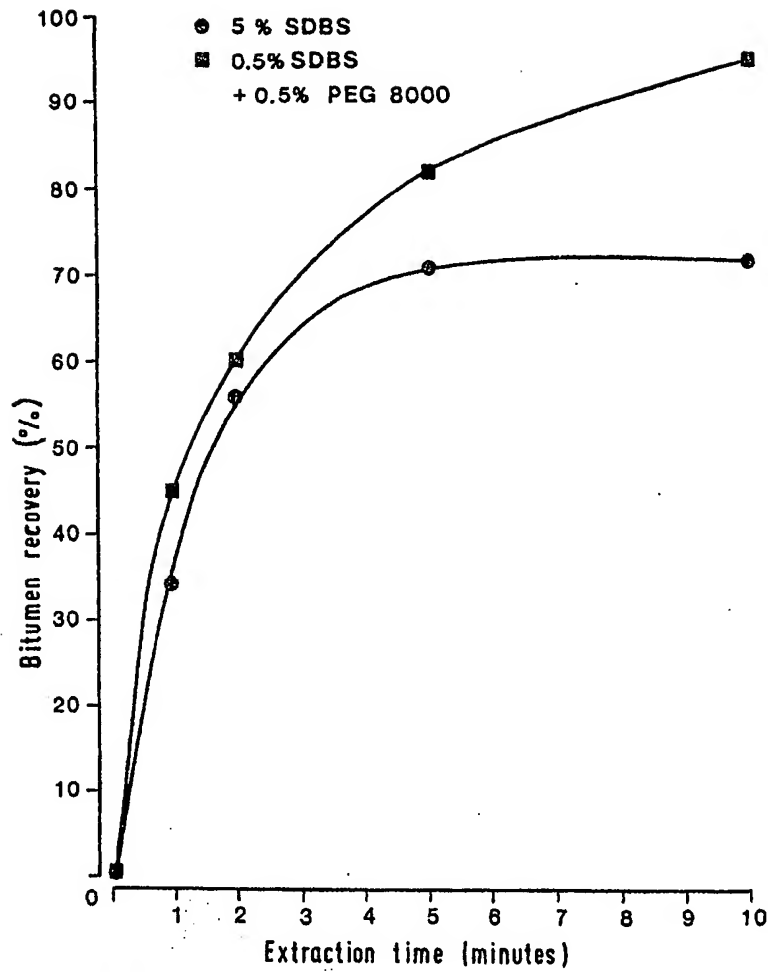


Fig. 2. Bitumen recovery vs. extraction time,
SDBS and SDBS/PEG 8000 mixtures at 100°C

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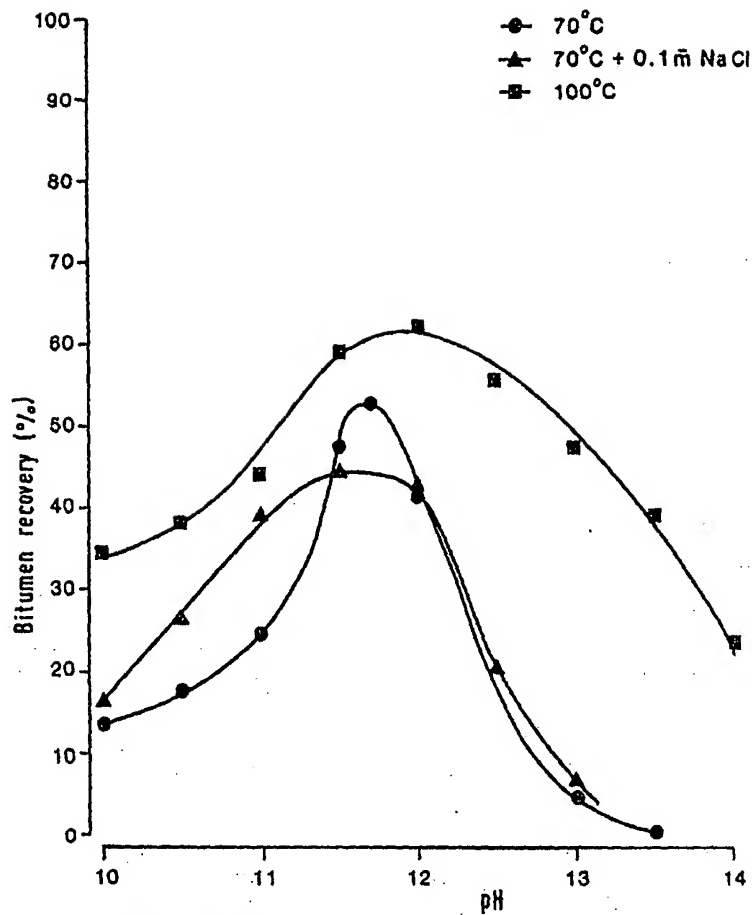


Fig.3. Bitumen recovery vs pH at 70°C and 100°C

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